An Analytical Study of Price Discovery of Equity Options in India

Research Proposal submitted in partial fulfillment of the requirements for the Degree of

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In
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By

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Introduction:

Derivatives: Derivative is a financial instrument the value of which is derived from the value of an underlying variable. The underlying variable can be a share, an index, interest rate, currency or any other. According to the Securities Contract (Regulation) Act, 1956 (SC(R)A) derivative includes-

1. A security derived from a debt instrument, share, loan whether secured or unsecured, risk instrument or contract for differences or any other form of security.
2. A contract which derives its value from the prices, or index of prices, of underlying security.

There are several variants of derivative contracts. Some of the common variants of derivatives are forward, future, option and swaps.

Forwards: It is a customized contract between two parties to buy or sell an asset at a certain time in the future at certain pre-agreed price.

Future: It is a contract between two parties to buy or sell an asset at a certain time in the future at a certain price. These are the standardized exchange traded contracts.

Options: These contracts give right to the holder of the contract to exercise the contract. These are of two types: Call Option and Put Option.

Option is a financial instrument whose value depends upon the value of the underlying assets. Option itself has no value without underlying assets. Option gives the right to the buyer either to sell or to buy the specified underlying assets for a particular price (Exercise / Strike price) on or before a particular date (expiration date). If the right is to buy, it is known as "call option" and if the right is to sell, it is called as "put option". The buyer of the option has the right but no obligation either to buy or to sell. The option buyer has to exercise the option on or before the expiration date, otherwise, the option expires automatically at the end of the expiration date. Hence, options are also known as contingent claims. Such an instrument is extensively used in share markets, money markets, and commodity markets to hedge the investment risks and acts as financial leverage investment. Option is a kind of derivative instruments along with forwards, futures and swaps, which are used for managing risk of the investors. Though derivatives are theoretically risk management tools and leveraged investment tools, most use them as speculative tools.

An option is a contract to buy or sell a specific financial product officially known as the option's underlying instrument or underlying assets. For exchange-traded equity options, the underlying instruments are stocks of listed companies. The contract itself is very precise. It establishes a specific price, called the *strike price*, at which the contract may be exercised or acted on and it has an *expiration date*. When an option expires, it no longer has value and no longer exists. Option is known as security, or contingent claim, or contract, or derivative security or simply derivative. An option gives its holder the right to purchase (sell), a specified quantity (lot size) of an underlying asset for a specified price (exercise price or strike price) on or before some specified date called expiration date, but the holder has no obligation to purchase (sell).

Index options: These options have the index as the underlying. Some options are European while others are American. Like index futures contracts, index options contracts are also cash settled.

Equity options: Equity options are options on individual share. Options currently trade on over 500 stocks in the USA. A contract gives the holder the right to buy or sell shares at the specified price

Option Pricing:

The price of the option is determined by many methods like binomial method, Black Scholes option pricing formula, Volatility jump model etc. out of which the Black Scholes option pricing model is most popular and widely used throughout the world. It is based on the assumption that the stock prices as per continuous – time, continuous – variable stochastic Markov process. Markov process states that the future value of stock price depends only on the present value not on the history of the variable. The Markov property implies that the probability distribution of the stock prices at any particular future time is not dependent on the path followed by the price in the past. The Markov property of the stock prices is consistent with the weak form of market efficiency.

The variables and the parameters that determine the option price are:

Life Period of option: As we know the value of option comprise of two values: Intrinsic value and time value. As the time passes and the expiry comes near the time value of the option goes down. On the other hand the intrinsic value depends on the ups and down of the underlying prices.

Exercise price: The exercise price is the price on which the trader is confident that the underlying will move in one direction beyond that price (up or down depending on the nature of option i.e. either call or

put). In case of call option lower strike price call options are highly priced and for put options higher strike price put options are highly priced.

Risk free interest rate: As the risk free rate of interest goes up the price of underlying tends to go up that leads to increase in the prices of call option and downfall in the prices of put options.

Volatility of stock return: The high volatility of stock return lead to the option prices to new highs and lows. It can be seen on the stock exchanges that the option contracts (whether call or put) are highly priced and highly volatile if their underlying return is highly variable and sensitive.

Current Stock Price: Simply, if the price of a stock goes up the call option prices will go up and the price of the put option will come down and vice versa.

Open Interest: Open interest means total no. of open positions at a time since the beginning of a contract. Increase in open position shows that the no. of fresh positions are increasing whereas recent open position in option contracts have not been offset yet. The price of the option contracts is affected by the total open interest depending on the factor whether the open position have increased on buying side or short side.

Trading Volume: Increase in trade volume of a specific contract will lead to price of that contract. For example increase in the volume of call option of a stock of a certain strike price will lead to higher call price of that underlying share.

Implied Volatility:To price an option, Black-Scholes pricing model requires as inputs the strike price, stock price, time to maturity, risk-free interest rate and expected volatility. Option price is the price which the option buyer pays to the option seller. It is also referred to as the option premium. Of all the inputs that go into the pricing model, only volatility is unobservable. This implies that the market participants price the options by arriving at a volatility estimate that impounds all the relevant information reflected in the historical prices and their knowledge about the market conditions that statistical models may fail to capture. Implied volatility is obtained by inverting an option pricing model and this volatility is considered the market's consensus estimate of future volatility. This implied volatility is set to be the volatility of the underlying asset over the remaining life of the option. Furthermore, if the market is efficient and the option pricing model is correct, the market's estimate the implied volatility is the best possible forecast of future volatility with currently available information. i.e., all information necessary to explain future volatility generated by all other explanatory variable in the market information set should be subsumed in the implied volatility.

Review of Literature:

Black et al (1972) admitted some biases of the model in their research paper, "*The Valuation of Option Contracts and a Test of Market Efficiency*", expressed as using the past data to estimate the variance caused the model to overprice options on high variance stocks and underpriced options on low variance stocks.

Extending the argument of Black and Scholes model Manaster and Rendleman (1982) contend that option market plays an important role as a trading vehicle that provides high liquidity, low trading costs, leverage, and least restrictions.

Bhattacharya (1987) adds upper bound on the loss if long in the option, as another factor that makes informed investors prefer option market. Complementing these results, Cassano (2001) concludes that the existence of option contracts reduces the gap between incomplete and complete markets to negligible.

Blume et al (1994) contend that volume provides information about the quality of trader's information, which cannot be deduced from the price statistic. They investigated the role of volume and trade information in Brown and Jennings Model (1989) and Grundy and Mcnichols Model (1989), and suggested the changes that need to be brought about in these models. They support complementarily in price and volume information and conclude that a trader who ignores volume would face penalty because the price impounds information about the average level of trader's private information while volume captures signals relating to the quality of trader's information.

Extending this study to establish the inter-linkage between option and stock market, Easley, O'Hara and Srinivas (1998) argue against the widespread belief that price in option market is unilaterally derived from the underlying stock prices. They develop a model using the technique of causality testing proposed by Granger (1969) and Granger and Newbold (1977) to investigate the relationship between the option volume and stock price changes to assess the informational content of option market and information lead-lag between cash and option market. The conclusions drawn from this study are twofold: (1) stock prices lead option volumes; and (2) option volumes lead stock price changes. The first conclusion is in line with the hedging argument while the second indicates that option market is an important venue for information-based trading. They propose the asymmetric information-based theory where the informed traders would trade in call and put options based on their private information which would convey useful signals to the other market participants resulting in an impact (positive or negative) on the price of

underlying stock. This is probably the first study that presents significant evidence of impact of option volumes on stock prices.

Bhuyan and Chaudhury (2001) examined the role of option market's open interest to capture information about the future movement of underlying stock and showed that the trading strategies based on this predictor yields better results as compared to the buy-and-hold and passive covered call strategies. Further, Bhuyan and Yan (2002) developed several price predictors from the open interests and trading volumes of individual stocks from the option market and concluded that these factors exhibit significant explanatory and predictive power for the future stock prices.

Srivastava (2003) examined the role of certain non-price variables, namely open interest and trading volume, from the stock option market in determining the price of underlying shares in cash market. In order to examine the significance of these variables, he used the call and put option open interest and volume based predictors as given by Bhuyan and Yan (2001). The results show that these predictors have significant explanatory power with open interest being more significant as compared to trading volume. The study provided deterministic parameters that could be used by the uninformed investors to predict the price of underlying shares using stock options market data and formulate the profitable trading strategies based on it. Finally, it provided support to the view that presence of option market improves the price discovery in underlying asset market.

Hentschel (2003) found that estimating implied volatility by inverting the Black-Scholes formula was subjected to considerable error when option characteristics were observed with plausible errors. He studied small errors in option prices and other option characteristics produced large errors in implied volatilities.

Shu& Zhang (2003) studied the relationship between implied and realized volatility by using daily S&P 500 index option prices for 5 years. They found the improvement of the measurement of realized volatility can significantly improve the forecast ability of implied volatility. They also found that when both implied volatility and historical volatility were used to forecast realized volatility, the implied volatility outperformed historical volatility and even subsumed information of historical volatility.

Sheng & Chiu (2007) introduced an innovational methodology to price European options with actual implied volatility distributions collected from historical samples. The empirical pricing performance test indicated that this pricing methodology with significantly smaller pricing error compared to Black & Scholes pricing model.

Choi et al suggested a model (Least Square Vector Machine Model) to estimate options' implied volatility. They used Hang Seng Index options to verify the performance of the model.

Srivastava et al (2008) investigated the significance of net open interest and trading volume on stock option market and stock index option market to predict the underlying stock prices/index level. In the study, only 15 stock option contracts (having maturity of one-month) and Nifty options for the entire

period, i.e., November 10, 2001 to November 2, 2004, have been analysed. The analysis could not be carried out for all the stocks in option segment because of the fact that the options were not traded or the trading range and volumes were too thin to justify any analysis. The major findings of the study are as follows:

• Net open interest of stock option is one of the significant variables in the determination of the future spot price of the underlying stock.

• Open interest-based predictors are statistically more significant than the volume-based predictors in the Indian context too as is the case for the US market.

• The trading behavior of Indian investors is found to be different from their counterparts in the developed world. This difference can be attributed to:

(i) The nascent state of derivatives market in India

(ii) Extremely limited participation of institutional investors in the Indian stock derivative market because of regulatory **restrictions**; as such investors are allowed to use derivative securities mainly for hedging and arbitrage purposes only.

Nagendran (2008) conducted an empirical study on Indian equity options that covered almost all the aspects of the model like sensitivity of the model to its variables/parameters, predictability of the model, weakness of the model like biases, validity of the assumptions of the model adequacy through residual analysis and improvement of the model.

But this study was conducted on the equity option contracts before year 2008. During that time equity option in India was American type option which is not as per the assumptions of the black scholes pricing model which assumes that the option should be a European option. The another limitation of the study was that the study was restricted only to the call option pricing using Black Scholes Model that could be extended to the pricing of put options. Further, to measure the predictability of the model, the concept of mean implied volatility could be used.

Some of the research studies for understanding the practical implementation of Granger Causality Test are:

Foresti (2006) focused on the relationship between stock market prices and growth. A granger-causality analysis was carried out in order to assess whether there is any potential predictability power of one indicator for the other.

Brahmasrene & Jiranyakul (2007) used Granger Causality test to examine the relationship between stock market index and selected macroeconomic variables during the post-financial liberalization and post financial crisis in Thailand.

Hossain (2010) investigated long run causal linkages between stock market development and economic growth by applying the Engle-Granger causality test.

Egbo (2011) found out the direction of causality between direct investment and economic growth in Nigeria for a period of 40 years from 1970 to 2009. To check the direction of causality, the Grangers causality test was employed and it indicated that causality ran from FDIs to GDP which showed a uni-directional relationship.

Rationale of Study:

There is very less work that has been done in the equity option in India. The reason behind this was that equity option was very new in the Indian derivative market and the studies which were carried out in India on equity options were very limited due the lack of volume in equity option market. Now, the trade volume in Indian Equity Option segment has been increased in recent years. Therefore, the pricing can be effectively done by using Black Scholes model and also the impact of various factors can be studied in a better way.

Objectives:

Primary Objectives:

1. To determine the determinants of Equity Option Pricing in Indian Stock Markets.
2. To determine the impact of "Implied Volatility" on option pricing in India.
3. To determine the impact of "Open Interest" on option pricing in India.
4. To determine the impact of "Trading Volume" on option pricing in India.
5. To determine the Causality Relationship between Equity Price in Cash Market and its underlying Call Option in Derivatives Market.
6. To determine the Causality Relationship between Equity Volume Traded in Cash Market and its underlying Put Option in Derivatives Market.
7. To determine the Causality Relationship between Equity Price in Cash Market and its underlying Put Option in Derivatives Market.
8. To determine the Causality Relationship between Equity Volume Traded in Cash Market and its underlying Call Option in Derivatives Market.
9. To develop strategies for pricing of equity call option in Indian Derivatives Market.
10. To develop strategies for pricing of equity put option in Indian Derivatives Market.

Secondary Objectives:

1. To understand the development of Indian Equity Derivatives Market w.r.t. the American Equity Derivatives Market.
2. To understand the application of American Call Option in Indian Derivatives Market.
3. To understand the application of American Put Option in Indian Derivatives Market.
4. To understand the application of European Call Option in Indian Derivatives Market.
5. To understand the application of European Put Option in Indian Derivatives Market.
6. To understand the application of the fundamental "Black Scholes Model" in Pricing of Equity Options.

Methodology:

The Study: Descriptive and Analytical

Option pricing using Black Scholes model (S-6) and determination of implied volatility (P-2).

Step I.First we will get the value of the share prices of the period of five year i.e. time period of study. (From 2009 to 2013)

Step II. Then we will get the standard deviation of the returns on the shares.

Step III. Further, we will get the data of strike prices of various shares and their option contract values.

1. **Black Scholes Model** will be used to calculate the fair price of an option contract.

   $$C = SN(d_1) - Ke^{-rT}N(d_2)$$

   Where N (d_i) = the cumulative standard normal distribution function, evaluated at d_i, and:

   $$d_1 = \frac{Ln(\frac{S}{K}) + (r - \frac{\sigma^2}{2})t}{\sigma\sqrt{t}}$$

   $$d_2 = d_1 - \sigma\sqrt{T}$$

   Here, $N(-d_i) = 1-N(d_i)$

   Applying Put-Call Parity, the put price is:

   $P = C - S + Ke^{-rt}$

2. For calculation of implied volatility the actual price will be taken and by putting the value of actual price in the B S equation we can get the value of volatility of the option contract i.e. the implied volatility.

Sample: Data is to be taken for top 20 stock options (based on trading volume) for year 2011 to 2013.

No. of Shares: 20

No. of days: 750

No. of options contracts (to be taken for the study): 10

No. of Data for empirical study: 1,50,000 (10x750x20)

Data Collection: Data will be collected from NSE website.

Type of Data: Secondary Data

Tool for Data Analysis:

Granger causality (P5-P8) is a statistical concept of causality that is based on prediction. According to Granger causality, if a signalX_1 "Granger-causes" (or "G-causes") a signal X_2, then past values of X_1 should contain information that helps predict X_2 above and beyond the information contained in past values of X_2 alone. Its mathematical formulation is based on linear regression modeling of stochastic processes (Granger 1969).

G-causality is normally tested in the context of linear regression models. For illustration, consider a bivariate linear autoregressive model of two variables $X1$ and $X2$:

$$X1(t)=\sum j=1pA11,jX1(t-j)+\sum j=1pA12,jX2(t-j)+E1(t)$$

$$X2(t)=\sum j=1pA21,jX1(t-j)+\sum j=1pA22,jX2(t-j)+E2(t)(1)$$

Where p is the maximum number of lagged observations included in the model (the model order), the matrix A contains the coefficients of the model (i.e., the contributions of each lagged observation to the predicted values of $X1(t)$ and $X2(t)$, and $E1$ and $E2$ are residuals (prediction errors) for each time series. If the variance of $E1$ (or $E2$) is reduced by the inclusion of the $X2$ (or $X1$) terms in the first (or second) equation, then it is said that $X2$ (or $X1$) Granger-(G)-causes $X1$(or $X2$). In other words, $X2$ G-causes $X1$ if the coefficients in $A12$ are jointly significantly different from zero.

Design for using Granger causality test

Null Hypothesis	Obs.	F statistic	P-value
X does not Granger cause Y			
Y does not Granger cause X			

If P-value is higher than 5%(>0.05) then Null hypothesis is not rejected i.e. X does not granger cause Y or Y does not granger cause X.

Direction of Causality	P-value	Lags	Decision	Outcome
X>Y	>5%		Do not reject Null	X does not cause Y
X>Y	<5%		Reject null	X causes Y
Y>X	>5%		Do not reject Null	Y does not cause X
Y>X	<5%		Reject null	Y causes X

In general, it is assumed better to take one third of no. of sample as a lag value.

(P-1) is based on Literature review.

For primary objectives (P-2, P-3 and P-4) are based on data collected andanalyzed using basic mathematical tools as percentage analysis and statistical tools as **correlation and regression analysis** using MS Excel.

(P-5 to P-8) could be done using Granger's Causality Test.

(P-9 and P-10) are based on the result from overall study.

Secondary objectives (S-1 to S-6) are based on Literature Review.

Scope of the Study:

1. The study will help to understand the impact of various factors on the stock option prices in the context of a developing country like India.
2. It will not only help to the investor community but also provide support in enhancing quality of stock price prediction.
3. This study will also create further scope for the research for option pricing in developing countries.

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